Using Economics in NOAA Performance Measures: The Role of Economic Performance Measures in GRPA

April 2002

PROJECT DIRECTOR

Rodney Weiher
NOAA Chief Economist

PRINCIPAL INVESTIGATORS

Charles S. Colgan PhD
Professor of Public Policy and Management
Edmund S. Muskie School of Public Service
University of Southern Maine

Thomas Teisberg PhD
Teisberg Associates
Charlottesville VA

Executive Summary

- Pursuant to the Government Performance Results Act, NOAA has identified a number of performance measures to assess progress towards achieving its policy goals in the following areas:[1]

  Build Sustainable Fisheries
  Sustain Health Costs
  Recover Protected Species
  Advance Short-Term Weather Warnings And Forecasts
  Implement Seasonal to Interannual Climate Forecasts
  Predict and Assess Decadal to Centennial Change
  Promote Safe Navigation

The chosen performance measures appropriately focus on the accomplishments of key NOAA programs.

- NOAA's performance measures do not develop information that would be useful in relating the resources required to accomplish its mission with the actual results achieved. The measures also do not address the actual outcomes that result from increased or improved services by NOAA.

- The addition of economic information in the suite of NOAA performance measures would address both of these deficiencies by providing information about resources used and about how people value the changes that result from improved NOAA Services.

- Early efforts should be on developing information about the economic benefits of NOAA's programs, as this provides the clearest way to move beyond outputs to outcomes.

- The addition of economic information to NOAA performance measures will require five steps.

1. **Inventory Existing Information** A large amount of economic information is available concerning most of the goal areas identified by NOAA, some conducted by NOAA agencies themselves, others by outside agencies. A comprehensive inventory should assess this information's scope, geographic coverage, methods used to obtain the information and the quality of the information.

[1] Draft of 09/11/2001. This paper focuses on the performance measures discussed in this draft from NOAA. The authors acknowledge that further development of performance measures may be taking place within the agency, which are not discussed here, and efforts along the lines suggested here may be underway in some parts of NOAA. It is hoped that the discussion in this paper will assist those efforts.

2. **Build on Current Procedures** Some agencies in NOAA already conduct extensive economic analysis. This provides an opportunity to establish improved economic information as a performance goal itself and develop improved information as the economic analysis of activities such as fisheries management plans are developed.

3. **Use Evaluation Opportunities** Evaluation of program outputs is an essential part of the performance measurement process. This involves conducting detailed assessments of program elements, including what is accomplished, how much it costs, whether the effects of the programs are in line with expectations. There does not appear to be a systematic effort to incorporate economic considerations into program evaluations in NOAA. This deprives NOAA of potentially useful information for specific programs, and loses an opportunity to collect economic information that can be useful in building economic performance measures. As regular program evaluation initiatives are planned, the potential to incorporate an economic component should be assessed.

4. **Build Data** A concerted effort will be needed to build the research base on which performance measures can be based in the future. The National Ocean Service is currently funding an effort (the National Ocean Economics Project) to develop part of the needed data, but this effort compiles existing information and there is much research that still needs to be done. This is particularly the case with respect to economic values associated with weather and climate. An economic research agenda could be developed from the assessment of existing information, the data developed in current procedures, and the evaluation process. This should be the precursor to a sustained effort to develop the required information upon which performance measures can be based.

5. **Redefine Mission** Performance measurement is ultimately an expression of an agency's mission. It is a feedback process in which information permits adjustments in how an agency manages its programs and what the agency does. The use of economic information in defining NOAA's performance measures will also suggest ways to redefine NOAA's missions. NOAA's missions could include such ideas as:

> Building and sustaining wealth from ocean resources.
>
> Enhancing the value of living in and visiting coastal communities.
>
> Providing needed information about the oceans and atmosphere to a wide variety of audiences.

The advent of the Internet and the ease of transmitting information makes NOAA much more than a provider of information to the scientific community. The National Weather Service has always had this role, but increasingly parts of NOAA such as the National Data Buoy Center are providing their information directly to the public. This expansion of NOAA's service roles is creating new kinds of economic values that should be explicitly acknowledged as part of gaining a broader understanding of NOAA's economic roles.

Introduction

Since passage of the Government Performance Results Act (GRPA) in 1993, federal agencies have been required to develop a set of outcome expectations for their major programs, along with measures by which to track performance towards their expected results. In conformance with GPRA, NOAA has defined its mission and goals and identified and set of performance targets for the various sections within the agency. These measures have been developed to reflect the variety of specific missions and programs undertaken by NOAA, and like most government performance measures, they include a mixture of different kinds of measures primarily of changes in the outputs of NOAA programs or in the physical environment affected by those programs. The Bush Administration is building on the GRPA with increasing expectations of performance measurement as part of the budget development and review process.

NOAA's performance measures provide a good guide to the agency's managers and constituents by which to assess programs, although using performance measures is still evolving. The approach is still new enough, and still something more imposed by outside forces (the Congress, OMB), that it is far from being internalized within the policy development thinking of most line managers. There has also not been enough experience with performance measurement over time to see how changes in the performance measures are manifested in policy and budget decisions.

This paper reviews the role of performance measures in government management and the role that economics can play in shaping concepts of government performance. It is meant to suggest ways in which NOAA agencies can employ economic analysis to improve their own understanding of their performance and missions. It begins with an overview of how performance measures and economics are related conceptually, and then discusses the approaches to economic analysis that would be useful under each of the broad performance goal areas that NOAA has defined for itself.

It should be noted at the outset that discussion of using economics in the performance measurement process is to focus on only one part of the policy development process. Better economic information can help many kinds of policy decisions in setting priorities within NOAA and its constituent parts. This discussion should not be seen as limiting the use of economic information only to the performance measure process. Rather, by focusing on a part of policy development which can be particularly aided by economic analysis and information, performance measurement provides an appropriate starting point for a broader consideration of how economic analysis can help NOAA meet not only the formal requirements of the law and budget process, but expand its concepts of what NOAA does and how it does it.

Performance Measures and Economic Analysis: An Overview

The passage of the Government Performance and Results Act in 1993 was actually the culmination of twenty years of efforts by the federal government to bring some system of accountability and performance assessment to bear on federal activities. In 1973, Congress created the Federal Productivity Measurement System, which related government activities to the amount of labor (employees and person hours) needed to undertake them. The 1980's saw the drive for "total quality management" in both the public and private sectors. TQM became the buzzword of the day throughout the federal government, and a Federal Quality Institute was created in 1988. (Thor, 2000)

Osborne and Gaebler's 1992 call for a more transparent and efficient government and their book *Reinventing Government,* came along at a time to capture the attention of Bill Clinton and Al Gore, who upon election, promptly initiated the National Performance Review (NPR). The NPR lead to GPRA, but in fact the idea of developing performance measures tied to programs was already established by the Chief Financial Officers Act of 1990 and a revision to OMB Circular A-11 that required performance measures to be included in budget submissions beginning in 1992. (Newcomer 1999).

The idea of performance measures has thus set off a search for appropriate measures to describe what government does. That search has been undertaken not only by federal agencies such as NOAA, but also by state and local governments throughout the United States and in many countries. Though the number of performance measures developed probably numbers in the thousands, virtually all fall into a fairly small number of categories, defined by the Governmental Accounting Standards Board (GASB):

Measures of Effort

Amounts of resources put into a program

Financial

Resources measured in dollars.

Nonfinancial

Resources measured in personnel, equipment, facilities.

Measures of Accomplishment

Measures of results of programs. These may be subdivided into measures of:

Output

Changes in what is provided as a result of the resources used. Changes may be in either or both:

Quantity of Services

Changes in the physical volume of services/products, etc.

Quality of Services

Changes in the quality of services/products, etc.

Outcomes

Changes that result from changes in outputs.

Measures Relating Effort to Accomplishment

Either outputs or outcomes may be compared to the level of resources used to calculate output/outcome per unit of resource used.

The following table arrays the various performance measures used by NOAA's various agencies according to this typology:

Table 1
Classification of NOAA Performance Measures

Measures of Effort	Financial		
	Nonfinancial		**NOAA Performance Measures**
Measures of Accomplishment	Outputs	Quantity of Service	Acres of coastal habitats benefited. Coastal regions with reduced exotics introductions. Shoreline with identified coastal hazards. Increased monitoring forecast products. Increased climate observations. Document turnover of CFC scores. Publish updated air quality trends. Develop ozone assessment for North America. Reduce backlog of hydrographic surveys. Complete National Spatial Reference System. Percentage of stocks rebuilding plans. Information on environmental effects of fishing gear.
	Quality of Service		Reduce stocks with unknown status. Reduced extinction probability for threatened/endangered species. Reduced extinction probability for threatened/endangered species. Reduced mortality for marine mammals. Lead-time /accuracy for severe weather warnings. 3 day weather forecast accuracy Accuracy of aviation forecasts. Accuracy of marine forecasts. ENSO forecast accuracy
	Outcomes	Direct	Decrease overfished stocks
		Indirect	
Measures of Accomplishment/ Effort	Cost/Output		
	Cost/Outcome		

It is clear from this table that NOAA has chosen to emphasize certain types of performance measures over others, particularly those involving measurements of either the quality or quantity of the outputs of its program initiatives. The measures chosen are quite appropriate to those programs, and avoid some of the pitfalls involved in performance measurement. NOAA has chosen measures that can be easily linked directly to its programs and actions, and thus there are very few "outcome" measures.

But in choosing to emphasize output measures, NOAA may be missing opportunities to develop a fuller understanding of its activities and improve its management. It is desirable that an organization's suite of performance measures should be balanced among measures addressing the needs of the *business,* the *customers,* and the *employees.* (Kaplan and Norton 2000) Though developed at the Harvard Business School primarily for private sector firms, the concept of the balanced measure strategy has been highly influential in the public sector as well. The National Partnership for Reinventing Government examined the use of the balanced measures approach by public agencies (NPRG 1999). The measures that were developed to address the needs of a "balanced scorecard" have varied, but have generally fallen into four broad categories: (Thor 2000)

Financial
Customer
Internal Business Processes
Learning and Growth

This concept of "balance" sees performance measures as informing four key aspects of an organization's management:

How well does the organization use its financial resource?
Does it serve its customers' needs?
Are the organization's structure and procedures serving its mission?
Is the organization increasing its knowledge to better function in the future?

In this framework, NOAA's performance measures may be said to address "customer needs" to some extent, but none of the other questions.

This brief analysis of NOAA's performance measures suggests that they represent a good start at assessing performance, but more could be done. Although they are focused on the needs of the "customers" of the agencies services, they only address what NOAA produces rather than looking beyond to the beneficial changes may result from those services. Moreover, there are no performance measures that relate measures of accomplishment to measurements of effort, and thus no way to specifically address the relationship between NOAA's performance and the resources required. It is in developing performance measures in these specific areas that economics can be of most use.

The idea of developing specific measurable objectives and outcomes for public programs actually originated with economists, who have developed the concepts of cost-benefit and cost-effectiveness analysis for precisely that purpose. The simplest way to think about economic performance measures is that they are designed to answer a simple question:

What do we get back for what we give up?

The answer to this question depends on defining and measuring first what we give up ("costs"), and then comparing these with a measurement what we get back. If we choose to compare costs only with outputs, in the sense discussed earlier, then the process is called cost-effectiveness analysis, which is actually just another name for the idea of accomplishment per unit of effort in the sense that GASB uses the term. Economists add a few rules about how to count costs in this type of analysis, but these need not be of concern here.

It is when we choose to compare what we give up with what we get back, now defined as outcomes rather than outputs, that economics is particularly helpful. For economics has a broadly useful definition of outcomes, that is economic benefits. As economists use the term, "benefits" has a very specific meaning:

Increases in the real value of goods and services that people find useful.

This definition implies several key ideas:

1. Benefits result when either the total value of goods and services goes up (more is produced), or when the price per unit of a good or service goes down. A benefit implies "more", "better", "cheaper", or all three.
2. Most importantly, benefits are those changes that affect people and that people put value on; thus, focusing on benefits reconnects the results of government programs to the economy and the people who pay for them.
3. It is real changes that matter, not hidden changes that occur because of forces such as inflation.

The concept of benefits in this sense has often been compared to the "profits" of a private firm, and thus the use of benefits meets the definition of "financial" measures within the balanced measure approach. This is a reasonable comparison at a broad level, but there are some important differences. The benefits from government activities are often difficult to measure, requiring some specialized economic techniques and concepts that will be explored in more detail below. A major reason for this measurement difficulty is that governmentally produced goods and services are rarely traded in markets, and thus there are no readily available market prices that can be used to place values on those goods and services.

In traditional national income accounting (i.e. measures of gross domestic product), government output is simply measured at its cost of production. While this

makes it easy to get a number for the value of government output, it fails to distinguish between outputs that actually increase *values* and those that do not. For example, it would not necessarily make sense to claim as a benefit an increase in spending on weather forecasting. Such an increase may "benefit" the NWS and its employees, but might or might not produce a net increase in value for the country as a whole. We do not know because this measure does not answer the question "what do we get back for what we give up". Indeed, counting increasing budgets as a benefit effectively assumes that an increase in costs (increased expenditures) was its own benefit and thus its own justification.

Applying the economic concepts of cost-effectiveness analysis and cost-benefit analysis can make it possible to construct a more complete set of performance measures. These more complete measures can include *outcome* measures in addition to outputs, and they can address not just what NOAA is doing, but how well it is using the resources assigned to it. Another important piece of information that economics can provide is *"who gets what"*. It is the distribution of the costs and benefits of a particular decision that is often the key determinant of the desirability from a political perspective.

It should be emphasized that these economic concepts are *not* substitutes for other performance measures that NOAA has chosen, but complements to them. They do not replace but add to NOAA's existing approaches. The information in those measures is a necessary precursor to the additional information that economic analysis could provide. (In order to understand the value of an improved weather forecast, we first need to understand the nature of the improvement.) Moreover, for some types of services, such as those involving preservation of endangered or threatened species, the use of economic analysis presents legal and analytic difficulties that make the use of economics in these areas probably inappropriate.

With this general introduction to the potential role of economics in improving NOAA's use of performance measures, we can proceed to examine some specific economic concepts of to NOAA. We continue at a fairly broad conceptual level, referring to some recent research of interest in this area, but recognizing that we cannot be aware of all the work that may be going on within NOAA to address many of the issues. Thus we begin with an apology to the many economists, financial officers, and others dealing with these issues who work in and with NOAA whose work we do not cite, and hope that the framework we offer for the use of their work will offset those omissions. We organize this discussion around the goal areas that NOAA has defined for itself:

Build Sustainable Fisheries
Sustain Health Costs
Recover Protected Species
Advance Short-Term Weather Warnings And Forecasts
Implement Seasonal to Interannual Climate Forecasts
Predict and Assess Decadal to Centennial Change
Promote Safe Navigation

We conclude with some suggestions for next steps that might be considered to take advantage of the opportunities for understanding NOAA's roles and functions offered by economic analysis.

1. Build Sustainable Fisheries

NOAA has identified the following performance measures for this goal:

- Reduce the number of overfished stocks of fish by 2007
- Increase the percentage of rebuilding plans in place for overfished major stocks
- Increase the adequacy of information required to address the environmental effects of fishing gear.
- By 2007 reduce the number of major stocks with an "unknown" stock status to no more than 60.

The focus of these measures is the reduction of over fishing, with an emphasis on the number of stocks that are defined as over-fished (an outcome), the number of plans to reduce over fishing in place, an increase in information about currently unassessed stock conditions, and increased information about environmental side effects of different types of fishing gear (all output measures).

These goals and performance measures are chosen to focus on efforts required under Magnuson-Stevens Sustainable Fisheries Act (1976, as amended in 1996), which establishes clear federal policy to assure the long-term sustainability of the nation's commercial and recreational fisheries. It has long been known that there is an important difference between a fishery that is at its maximum biological potential and one that is at its maximum economic potential, and U.S. fisheries policy reflects this distinction. As originally enacted, the Magnuson Act set as the goal of policy the attainment of optimum yield in a fishery, defined as "the amount of fish which will (a) provide the greatest overall benefit to the Nation, with particular reference to food production and recreational opportunities, and (b) is prescribed as such basis of the maximum sustainable yield from such fishery as modified by any relevant economic, social, or ecological factor".

The principles that define the economically optimum fishery are well established. A fishery is economically optimal when the amount of capital and labor is used most efficiently and the net economic benefits to the nation are maximized. This is defined as the point where the marginal cost of harvesting equals the marginal benefit (the revenues to harvesters and producers, less any external costs) of catching fish. The measurement of the conditions leading to economically optimal yield requires fairly extensive data, most of which is not readily available.

The National Marine Fisheries Service recognized this in a 1996 paper (*Economic Status of U.S. Fisheries*). In that paper, NMFS laid out both the economic theory of an optimal fishery and identified the data needed to measure the attainment of optimal fisheries. The following table is taken from that paper:

Table 2
Economic Information for Fisheries Management

Source: NMFS

	Available Routinely in Fisheries Management Plans	Available in Some Fishery Management Plans	Available only by special study	Not Available
Ex-vessel landings, prices, and revenues by species and vessel types	●			
Fixed and variable costs of production by vessel type			●	
Bycatch volume and type by fishery		●		
Population of vessels by size and type		●		
Estimation of optimal vessels by type				●
Balance sheets of vessel fleet by type			●	
Seasonal length of fishery	●			
Number of days fished by vessel		●		
Number of full and part-time harvesters		●		
Estimated of optimal landings and prices			●	
Economic value (producer surplus) at current and optimal levels			●	
Economic value of controlled access measures			●	
Socioeconomic characteristics of harvesters			●	
Costs of administration, monitoring, and enforcement of controlled access plans				●

If all of the economic information NMFS identifies as important for fisheries management were available, what would appropriate performance measures be? There are actually a number of options for defining appropriate economic performance measures for fisheries:

One would be the *number of fisheries at or approaching optimal sustained yield*. An estimate of long-term potential (maximum sustained) yield would be made, as is done now for fishery management plans. Then an estimate of the most efficient level of capital and labor would be added to identify the most efficient level of vessels, gear, and fishing employment needed to meet consumer demand without reducing the long term potential

stocks. This calculation would have to be performed for each fishery (defined as a commercially-exploited population of fish *and* the harvesting activities using that population), making it a fairly complex process.

Another approach to measuring the change in economic value is to use a *"capital stock" model for fisheries*. This approach would consider a fish stock as having the same characteristics as any capital asset such as a building or piece of equipment. It is thus a resource that can yield future returns of income. It is subject to depletion (natural plus man-induced mortality) as well investment and regeneration (natural plus managed activities that permit growth in both the total population as well as the size of fish). From this perspective, a fishery could be entered into traditional accounting frameworks for the value of capital stocks, such as the concept of "net national product". This is the measure within the national income and product accounting framework that measures the output of goods and services in the economy less the investment needed to replace capital equipment that has become fully depreciated. Such an approach has been under development in some fisheries on an experimental basis.

A somewhat simpler, but also somewhat less accurate, outcome measure of value would be the *size of commercial fishing in the national income and products accounts*. This would reflect the value to the final consumer of all fish caught and sold in the U.S. plus fisheries exports to other countries (less fisheries imports). This measure could be disaggregated to identify employment and income (both personal and business) generated in the production of the fisheries GDP. Components needed to estimate this value are available from various data sources, but an estimate would have to be constructed.

The suggestion that outcome measures involving optimal fishing effort, net national or gross domestic products, or employment and income be used raises a question about the directness of the connection between NOAA's activities and the values associated with these measures. NOAA itself has addressed this issue in part. In an earlier version of their performance measures, there was a measure of "increase in employment in noncapture fishing and other sectors in fishing communities". But this measure was dropped because of data availability issues and because the measure did not "reflect the roles and responsibilities of NOAA".

The intent of the measure was to address increases in the indirect employment associated with fisheries in certain communities, and NOAA's assessment of it as useful performance measure was sensible. Measuring the indirect employment effects is both difficult and not directly related to NOAA's mission. However, it may be appropriate to develop measures of the direct economic values affected by NOAA's decisions, and this can be done as the NMFS 1996 paper suggests.

Although the list of needed information is five years old, it is unlikely that many of the items have been moved into the "routinely available" category. As a result, NMFS is not in a position to develop national economic performance measures for the fisheries until after a significant investment is made in collecting the information, at least about each major fishery. This investment is very difficult to make with current resources,

since what economic research resources NMFS has are primarily committed to the development of highly specific information needed to meet legal and administrative requirements of individual fisheries management plans. Such information is certainly part of the needed economic information for fisheries management, but by being developed on a case by case basis for specific administrative task, the overall picture of fisheries management across the country emerges only in bits and pieces.

The measurement of economic values in the commercial fisheries, particularly as it addresses the economic efficiency of management arrangements, is clearly the most pressing economic measurement question affecting NOAA's management of the fisheries, but it is not the only economic information needed for the fisheries. Recreational fisheries are also a major use of the fisheries resources of the U.S., and fall at least partly within the management responsibilities of NMFS. NOAA has not specified a performance measure for recreational fisheries, but there are economic approaches to understanding recreational fishing that could be particularly important. Output measures might include the number of days or participants in recreational fishing, but a more useful outcome measure would be the economic value of recreational fishing.

The economic value of recreational fishing has sometimes been inappropriately measured by the total expenditures on recreation fishing, but this is only a partial picture of the economic activity associated with recreational fishing. This is so for two reasons. First, since much marine recreational fishing takes place with little or no per trip expenditures, a measurement of expenditures would account for such activity as party boat trips, but not for many other types of recreation.

Second, expenditure data confuses the question of what is the appropriate outcome. It is not the opportunity to spend money purchasing goods and services, but the opportunity to catch fish that is important to the recreationist. The correct measure of this outcome is the economic value to the recreationist of a fishing trip. This value, which economists call consumer surplus reflects what someone is willing to pay for a day spent in fishing.[2] It is measured through a variety of survey and other indirect techniques. This consumer surplus value is the more appropriate measure of outcomes because it reflects the quality of the recreational fishing experience as well as the quantity of actual activity. The "quality" of recreational fishing is a function of the type of fish caught, the probability of success, etc., and thus as the quality of the recreational experience increases, so should the economic value.

The lack of sufficient data to develop national performance measures of progress towards an economically optimal fisheries should not be seen as a reason for ignoring the question of the economic status of fisheries in measuring NOAA's performance. Several measures could be adopted consistent with the current approach that would identify the need to make progress in this area and to assess progress. Such examples could include:

[2] Studies of such values that are not determined through standard market transactions require the investigation, often through surveys, of a simulated market structure. In such cases, it is often easier to posit in the survey that one is being asked the price at which one is willing to sell the right to engage in recreational fishing rather than a hypothetical willingness to pay for a permit.

- Number of fisheries management plans (FMP's) with sufficient data and analysis to permit estimation of optimal fishery effort. (This has been used as a performance measure for NMFS.)

- Improvements[3] in economic data collection systems, which could focus on selected elements of the NMFS economic data list (such as financial or employment information).

- Increased frequency and coverage of non-market recreational fisheries values through regular surveys.

Another type of performance measure which has not been addressed is the effort/accomplishment type, which implies use of either cost-benefit or cost-effectiveness analysis. It would clearly be desirable to apply cost benefit analysis to decisions involving fisheries management, since the information derived from this analysis can shed important light not only on the overall outcomes of management programs, but can also help choose among different approaches to management. It can also help inform some of the complex choices that must sometimes be made between commercial and recreational fisheries and among different commercial fisheries. But the information that is needed to measure both benefits and costs is much the same as that discussed above, and so the applications of cost benefit analysis at this stage must be considered very limited.

Cost effectiveness analysis is likely to play a limited role as well. In general, cost effectiveness analysis is an appropriate tool when there is more than one "technology" for accomplishing a specified goal (defined in non-monetary terms). The outputs that NOAA has selected are largely related to specific program elements (except for the measure involving overfished stocks), and there may be no meaningful sense in which these outputs can be produced with more than a single technology. However, cost per unit of output for fishery management plans may be a somewhat useful measure, as there may be more than one way to produce a fishery management plan. In adopting this approach, it would be important to include litigation costs and time to prepare plans, which are significant costs born by the private sector as well as by the public sector. A cost effectiveness measure, or some similar approach, would provide a potentially useful measure of the efficiency of internal processes within NMFS, though the requirements of the relevant laws for the most effective means be chosen will still control.

Another economic measure related to cost effectiveness would be to use the disaster financial assistance that NOAA offers to certain communities in the event of severe economic disruptions associated with declines in effort required as fisheries stocks are rebuilt. Since disaster declarations are subject to political determination, this measure may be difficult to use, but setting goals of minimizing the need for such

[3] The adequacy of "improvements" and "increases" (following bullet) are matters of managerial decisions within the agency.

expenditures would reflect both the ability to avoid such disruptions and the need to minimize their duration.

2. Sustain Healthy Coasts

NOAA identifies three performance measures in this goal area:

- Number of acres (cumulative) of coastal habitat benefited
- Number of coastal regions with reduced introductions and impacts of non-indigenous species
- Cumulative percent of shoreline and inland areas with improved ability to identify extent and severity of coastal hazards

There is a large literature of studies on the economic value of wetlands, which might inform the creation of performance measures on the benefits of coastal wetland protection and restoration measures, much of directed to measuring economic values that can be used in cost benefit studies of proposals to alter or destroy wetlands.

However, the methodologies for valuing wetlands remain somewhat undeveloped. Attempts have been made to value the "services" provided by wetlands such as habitat, water filtering, etc. Other approaches have tried to measure the values of wetlands by using contingent valuation surveys to measure the value of wetlands, but both these approaches suffer from imperfect information about the nature and function of specific wetlands, which impedes the formation of meaningful expressions of economic value. (Colgan, 1993; Whittington, 1993) Nonetheless, measures of economic value of wetlands could offer insights into the changing quality of wetlands and thus add depth and scope to a measure of improved wetlands that considers all wetlands essentially the same. Better measures of the economic value of wetlands are also a necessary precursor to using cost benefit analysis to help set priorities in wetlands programs.

The extent of damage done by non-indigenous species has come to be recognized over the past decade as a major issue. A 1993 study by the Office of Technology Assessment estimated the costs of exotics as about $1 billion a year. (OTA, 1993) A study in 1999 estimated the cost at over $130 billion. The costs involved include both the costs of damage and control. The difference between these two studies is primarily in the number of species examined, but also in improved estimates of the actual extent and nature of the damage being done. The 1993 estimated economic costs from the zebra mussel at $300 thousand, but both increases in the spread of the mussel and better understanding of its effects led to an estimate of over $5 billion in 1997. (Khalanski, 1997)

Economic studies of the damage wrought and costs incurred to control non-indigenous species in coastal environments present good opportunities to add outcome measures for these NOAA programs. In developing performance measures with such studies, it may be desirable to separate control costs from damages in order to provide a

clear message about performance, since a reduction in damages represent the outcome, while control costs represent program outputs.

NOAA's measure on coastal hazards focuses on the identification of such hazards and the proportion of coastal areas (both shore and inland) where hazards are identified. This measure is directly related to NOAA's programs in this area. It does not address the ultimate outcome of such efforts, which is to reduce the damages from coastal hazards. There are a variety of good economic estimates of the damages from coastal hazards, and these could be used, but there are reasons to be cautious in using economic measures of hazard reduction.

The first is that the responsibility for hazard reduction spreads across many federal, state, and local agencies. It would be entirely appropriate to develop a performance measure crossing the range of federal agencies and programs dealing with coastal hazards to set a long-term goal of reducing the economic damages associated with such hazards. However, this would raise another issue, which is that the most significant economic damages associated with hazards tend to result from large scale but infrequent events such as hurricanes. Such events are unpredictable in size and frequency, and thus make designing a performance measure difficult.

The three performance measures that NOAA has chosen all focus on the reduction or elimination of damages and economic costs associated with changes in the coastal environment. There are two other areas where NOAA's goals of sustaining healthy coasts do not have listed performance goals, but for which economic performance measures may be useful. These are "promote clean coastal waters" and "foster well-planned and revitalized coastal communities".

There are a large number of studies that have measured the relationship between clean water and increased economic values. Some studies have looked at the impact of poor water quality on economic uses such as recreation, while others have looked at the changes in economic use following efforts to clean water. These studies should be investigated to determine whether there is a sufficient methodological and empirical basis for using these studies as a baseline for assessing performance on NOAA-specific programs. Since clean water is a joint responsibility with other agencies, particularly EPA, it may be desirable to establish joint performance measures in this area.

The goal of "well-planned and revitalized coastal communities" encompasses such a wide array of possible outputs and outcomes that it is difficult to identify specific economic measures that may be useful. An effort is currently underway to elaborate on elements of this goal and determine what performance measures, both economic and non-economic, may be appropriate. One area that might be considered in this effort is the growth in recreational economic values from coastal recreation opportunities. The coast is clearly a key resource for a wide variety of recreational opportunities, which are enjoyed by both coastal and non-coastal residents. Such recreational opportunities are surely one of the hallmarks of well-planned coastal communities. A measure of the growth in the net economic value of such coastal recreation activities as beach-going,

boating, site-seeing, and recreational fishing (discussed above) would provide an excellent measure of changes in both the quantity and quality of available opportunities.

3. Recover Protected Species

NOAA has chosen the following performance measures for this goal:

- Reduce the probability of extinction of 10 out of 27 threatened species.
- Reduce mortality of strategic marine mammal stocks incidental to 15 commercial fishing operations in 15 fisheries.
- Reduce the probability of extinction of 11endangered species.

Economists have been doing research in the economic values associated with the both the non-consumptive use of protected resources (such as whale watching) as well as people's valuation of the continued existence of protected species. These studies provide information that may be useful, although much of the research produces potentially widely varying values. The protection and recovery of endangered and threatened species is an area where economics is likely to be of limited use for two reasons. First, while economic studies of the benefits of protecting threatened and endangered species have been done, they are of limited value in setting priorities for federal actions because the legal requirements of the Endangered Species and Marine Mammal Protection Acts are the controlling factors in these programs. Second, within the activities governed by those acts, there are limitations on how economics can be used in deciding on the degree of protection to be offered. This is one of the few areas where consideration of the kinds of tradeoffs that economics is particularly helpful in identifying is limited. Nonetheless, economic information in the form of cost-effectiveness assessment of alternative means for dealing with protected species may still be highly important as part of the policy process in this area.

However, for any given degree of protection for a particular species, there are still legitimate questions about finding the lowest cost way of achieving that protection. In other words, this is an area where development of effort/accomplishment, or cost effectiveness measures, may be most important. Understanding and measuring the costs of protecting species should include the costs incurred by the public through the government programs and activities, including planning, policy development, implementation, and enforcement. It should also include the costs born by other parties. The goal should be minimizing total costs for any chosen level of protection, but a thorough accounting of costs should also help inform decisions about the appropriate distribution of costs between the public and private sectors.

4. Improved Short and Long Term Weather Forecasts

We group three NOAA goal areas into one here since all three require essentially the same economic approach in developing outcome measures. These three goal areas, with their associated performance measures, are:

Advance Short Term Warnings and Forecasts

- Lead time, accuracy, and false alarm rate for severe weather and tornadoes
- Lead time, accuracy, and false alarm rate for flash floods
- Lead time for hurricanes
- Lead time for winter storms
- Accuracy and false alarm rates for ceiling and visibility in aviation forecasts
- Accuracy for winds and waves in marine forecasts

Seasonal to Interannual Climate Forecasts

- Accuracy of ENSO forecasts
- U.S. Temperature
- Number of new monitoring or forecasts products made operational
- New climate observations introduced

Predict and Assess Decadal to Centennial Change

- Document the turnover of CFC source gases
- Publish updated trend results of air quality measures
- Lead development of annual assessment of region ozone in North America
- Results of the 90% of research activities cited in 2001 IPCC Assessment of Climate Change

What these have in common is that they all involve improving the information provided by NOAA's various atmospheric research and forecasting endeavors. Such information has economic value, and recent studies have begun to identify and measure that value in such a way that real outcome measures can be formulated for these activities.

An economic value exists when the forecast makes it possible to take action in advance of the forecasted event, and when that action reduces costs that would be incurred or increases economic benefits that might be created. When measuring a change in costs incurred from a forecast, we look at the difference between costs of the actions taken based on a forecast (boarding up the windows if a hurricane threatens) and the costs avoided (replacing the windows after the hurricane). Adjustments to cost estimates must also be made to reflect what happens if the forecasted event does not come to pass, as then there will typically be no offsetting cost reductions or benefits. On average, however, the costs of preparatory actions will be less than the subsequent cost reductions or benefit increases.

Lead time and forecast accuracy, which may be subdivided into accuracy as to time, place, and intensity and a minimization of false warnings, influence the net economic benefits derived from a forecast. With more lead time, a greater range of preparatory actions becomes possible, as NOAA recognizes by choosing this as a

performance measure. Some of this greater range of actions may be significantly more effective or less costly than the actions that are possible with less lead-time.

Two problems of false warnings limit the usefulness of forecasts. One is failure to predict an event that subsequently occurs (false negative). In this case, there is no opportunity to take anticipatory actions. The other error is a false alarm (false positive). In this case, the costs of preparatory action will be incurred unnecessarily. Thus, longer lead-time, higher forecast accuracy, and lower false alarm rates will translate into a higher economic benefit from forecasts. In the paragraphs that follow, we discuss the ways in which these concepts might be applied to the specific NOAA performance measures listed at the beginning of this section.

Tornadoes develop quickly. When conditions favor the development of tornadoes, the National Weather Service may issue tornado watches. These alert people to the possibility of tornadoes and may increase the number of people who actually receive a tornado warning, if one is subsequently issued. Tornado warnings are issued when an actual tornado is observed either by radar or by spotters. These warnings can be provided only minutes in advance. Thus, they provide only time for people to seek shelter. Finding appropriate shelter will reduce death and injury. Property damage, however, cannot be reduced in the short period of time before a tornado may strike.

Two kinds of information would be needed to assess the economic benefit of increased tornado warning lead-time. The first is a monetary valuation for human life and a monetary valuation for human injuries. While such valuations are difficult to make and often controversial, these kinds of valuations are commonly used across a spectrum of public policy decision making, including use by a number of Federal agencies such as EPA.

The second kind of information is an assessment of how tornado death and injury rates depend on minutes of tornado warning lead-time. Presumably death and injury rates are reduced with increasing lead time as more people may receive the warning in time to act, and those who do receive the warning may have more time to take appropriate actions in light of the warnings.

Improved tornado warning accuracy has economic benefits that are similar to those of increased lead-time. That is, with greater accuracy, there are fewer tornadoes that occur without any warning, and there is less loss of life. To estimate the economic benefits of improved tornado warning accuracy, one would want to understand the statistical injury and death rates for the types of tornadoes that may occur without any advance warning from the weather service. These tornadoes may or may not be statistically similar to the tornadoes, for which warnings are more likely to be issued.

Reduced false alarm rates would generate economic benefits in a slightly different way. Since responding to a tornado warning is a relatively simply thing to do, there are not large economic costs associated with responding to a tornado warning that turns out to be a false alarm. On the other hand, if the rate of false alarms becomes high, the public

may develop and attitude that warnings are not to be taken seriously. In this case, the cost of false alarms is additional death and injury. To assess the benefits of reduced false alarms, therefore, one would need to understand the relationship between false alarm rates and the seriousness with which the public takes warnings.

Floods cause more deaths than any other weather related disaster. Flash floods can be particularly deadly because warning times are usually short. As with tornadoes, there are watches and warnings issued. A watch indicates that people should be prepared for possible floods, while a warning indicates that a flood is imminent. Flash flood warnings tend to provide only enough time to protect human life. Thus the economic benefits associated with flash flood warnings are driven by the value of human life. Additional minutes of lead-time would allow warnings to reach more people and allow more people to respond appropriately to warnings.

Accuracy and false alarm rates for flash floods would affect the economic benefits in the same ways as for tornadoes While improved accuracy is one of the stated performance goals, reduced false alarm rates is not mentioned as a performance measure. However, it could be made a performance goal.

In some sense, hurricanes are more predictable than either tornadoes or flash floods. This is because these are large storms that develop over open oceans and persist for days. However, forecasting the exact path of the hurricane and its intensity when it reaches land remain difficult challenges.

Because hurricane landfalls can usually be predicted with reasonable accuracy about a day in advance, such predictions allow for steps to be taken to protect property as well as people. Protections for property involve securing outdoor items, especially boats, moving furniture and valuables to a higher level in the home, and protecting windows with plywood or shutters. Protection for people involves moving people out of particularly susceptible buildings, such as mobile homes, having people remain indoors away from windows, and in some cases, general evacuation.

When forecast lead times are longer, there is more time to accomplish the steps involved in protecting people and property. To estimate the economic benefit of longer forecast lead time, one would want to know how the extent of preparedness increases with lead time and how the extent of damage, injury, and death is reduced with greater preparedness. One would also need to know how the costs of preparedness are affected by the amount of preparation that occurs, since the costs of preparing for hurricanes can be very substantial. As with tornadoes and flash floods, the accuracy and false alarm rates would also affect the economic benefits derived from hurricane warnings, though accuracy and false alarm rates for hurricanes are not listed among the performance measures.

Unlike the case with dangerous storms, other kinds of weather forecasts have economic benefits that are more difficult to identify and quantify. A 3-day precipitation forecast may be of use to farmers, builders, fishermen, and in other industries where

weather affects economic activity. The 3-day precipitation forecast may also be of use to households planning recreational activities or landscape activities. However, such benefits are widely diffused through the economy, and probably not overwhelming important in any sector of the economy. This does not mean that the economic benefits of improved 3-day precipitation forecasts are non-existent, but it does mean that they are hard to identify and quantify.

Winter storm warnings are similar in nature to hurricane warnings, in that winter storms can be predicted with at least several hours to several days lead-time. The effects of winter storms are well defined, and the actions taken to minimize effects are relatively easy to identify. These include effects on transportation systems, especially road and air travel and power systems. Winter storms also lead to school closures. With an accurate forecast, these closures can occur when necessary and be avoided with unnecessary.

The first step in quantifying such benefits would be to obtain good information on who uses of the forecasts and the economic values associated with their activities. If such information could be obtained, one could proceed to assess the value of forecasts in each case. This value would depend on the actions that are taken in response to a forecast, the costs of those actions, and the benefits of those actions. Finally, one would determine how the value of these forecasts increases as the accuracy of the forecast improves.

In the area of marine forecasts involving wind and waves recent studies have identified the economic value associated with improved coastal ocean observing systems that add to the number of monitoring stations and frequency of monitoring. (Colgan and Kite-Powell, 2001) Information from these coastal observing systems has economic value for navigation, search and rescue operations, fisheries, and marine pollution clean up and remediation.

As with short-term forecasts, the economic benefits of seasonal to interannual forecasts derives from the ability to use these forecasts to minimize the costs or maximize the benefits anticipated from a particular weather situation. Generally, benefits depend on the availability of actions that can be taken within the lead-time of the forecast, the costs or benefits that arise with and without taking these actions, and the probabilities of these weather events with and without the forecast. Seasonal to interannual climate forecasts have long lead times by definition, and in this respect they are likely to have significant values.

The field of long range weather forecasts is one are where significant work has already been done to estimate the economic benefits of improved forecasts. This work has primarily focused on the benefits of improved forecasts of the El Nino- Southern Oscillation (ENSO_ phenomenon. One study (Solow et.al. 1998) found that ENSO forecasts might be worth up to $300 million per year for US agriculture, depending on forecast accuracy. Other studies (Chen and McCarl 2000; McNew 1999) find similar benefits from ENSO forecasts. These kinds of studies usually rely on a value of information approach to estimating benefits, and would provide a means to directly estimate the increase in benefits that would result from a given improvement in forecast

accuracy. This approach might make it possible to specify ENSO forecast performance measures that are directly tied to incremental economic benefits. These kinds of studies might also suggest methods that could be adapted to develop similar benefit numbers for other stated NOAA performance measures, for example in the short term weather forecasting area.

Forecasts of decadal to centennial climate change are the same, in principle, as other shorter-term forecasts. However, these kinds of forecasts are inherently more difficult to value because of the long time frame and great scientific uncertainty involved. In addition, the stakes are very high in climate change, since climate change itself may be very costly, and the public policy measures proposed to mitigate climate change are also very costly. In this context, it is simultaneously true that estimating the value of climate change forecasts is difficult, and the value of such forecasts is likely to be extremely high. Among the few early efforts to estimate the value of information about climate change are studies by Manne and Richels 1992, Peck and Teisberg 1993, and Nordhaus 1994.

Realistically, it is hard to see how NOAA performance measures could be directly specified in terms of the value of information regarding climate change simply because economic values are not sufficiently stable across such long time periods. However, it may be possible to make use of existing climate change studies to identify key uncertainties, i.e. those for which uncertainty reduction is likely to have high economic value because they generate benefits in the near term. Then, NOAA's performance measures might be specified in ways that direct its efforts toward activities that tend to reduce the key climate change uncertainties.

5. Promote Safe Navigation

NOAA's performance measures for this goal are:

- Percent reduction in the backlog of hydrographic surveys for critical areas
- Cumulative percentage of National Spatial Reference System complete

The economic benefits of safe navigation are easily calculated based on the types and volumes of vessel activity, the extent of navigation hazards, and the extent to which those hazards are inadequately charted or the extent to which tide and current tables are inaccurate. This is one case, however, where the economic relationship of interest can probably be captured without a complete economic analysis. There is a likely relationship between high marine traffic areas and the risk of damage from inadequate navigational information. Thus, a prioritization of improved hydrographic and sea level measurements for the National Spatial Reference Systems based on marine activity would probably serve to direct NOAA's efforts so as to achieve maximum economic benefits. At the same time, to the extent the potential damages resulting from inadequate navigation information can be measured, the economic benefits and costs of navigational surveys can be compared to better define goals and performance measures, at least for some high traffic areas.

Conclusions: Strategies for Economic Performance Measures

The use of economics in performance measures for NOAA is important because economics establishes the direct path between NOAA's programs and the people they serve. The use of economic analysis will permit NOAA to significantly expand its suite of performance measures to extend beyond the output measures it focuses on with current information, to develop meaningful *outcome* measures, and to assess both outputs and outcomes in relation to effort. The result will be a more balanced and informative set of performance measures by which to guide NOAA's efforts, assess what it does and how efficiently it does it.

The absence of economic performance measures from NOAA's current suite reflects less a desire not to use them then recognition of the lack of information available. While it may be desirable to develop economic measures in each of the goal areas, it is unlikely that it can be done quickly or cheaply. Therefore strategies must be developed to start with what is available and build from there. The early focus of strategies to make use of economic information in performance measures should be on developing information about the economic benefits of NOAA programs. This is the information that is often lacking and represents the clearest measurement of outcomes.

The following steps may be a helpful guide to building economic information into NOAA's performance measures:

a. Inventory existing information

A large amount of economic information is actually available concerning most of the goal areas identified by NOAA, some conducted by NOAA agencies themselves, others by outside agencies. Economic benefits are already being measured for a variety of NOAA activities in the climate and weather areas; significantly less benefit data is available about many key ocean and coastal programs**.** The inventory should assess:

Scope of information
Geographic coverage
Research methods and quality

The Social Science Panel of NOAA's Science Advisory Board has recently completed an assessment of social science information that is produced and used by NOAA. This assessment may provide a good beginning to the inventory process.

b. Build on current procedures

Some agencies in NOAA already conduct extensive economic analysis. This is particularly the case with NMFS. As suggested above, this provides an opportunity to establish improved economic information as a performance goal itself, at least in the near

term as NOAA builds capacity to use economics, and develop improved information as the economic analysis of existing programs (such as fisheries management plans) is developed.

c. Use Evaluation Opportunities

Evaluation of program outputs is an essential part of the performance measurement process. This involves more than just collecting the appropriate data for the measures and assessing progress towards the attainment of defined goals. It means conducting detailed assessments of program elements, including what is accomplished, how much it costs, whether the effects of the programs are in line with expectations (both of the agency and its customers"). The evaluation of NOAA's programs takes place through both internal and external peer reviews and through what are described as "extensive informal networks". NOAA also noted that some of its research is subject to review in the process of litigation. Input from constituencies is also sought. There are also periodic special program evaluation studies conducted.

However, there does not appear to be a systematic effort to incorporate economic considerations into program evaluations. This not only deprives NOAA of potentially useful information for specific programs, it also misses an important opportunity to collect economic information that can be useful in building economic performance measures. As regular program evaluation initiatives are planned, the potential to incorporate an economic component should be assessed. In doing so, cross-agency communication about the use of economic analysis in evaluations should be as complete as possible in order to avoid duplication.

4. Build data

While the incremental use of past and current opportunities for research will form a foundation for using economic analysis for performance measures, it will not be sufficient. A concerted effort will be needed to build the research base on which performance measures can be based in the future. The National Ocean Service is currently funding an effort (the National Ocean Economics Project) to develop part of the needed data, but this effort compiles existing information and there is much research that still needs to be done. This is particularly the case with respect to economic values associated with weather and climate. An economic research agenda could be developed from the assessment of existing information, the data developed in current procedures, and the evaluation process. This should be the precursor to a sustained effort to develop the required information upon which performance measures can be based.

5. Redefine Mission

Performance measurement is really a feedback process, from which information is developed that permits adjustments to be made in both how an agency manages its programs and also to make adjustments in what the agency does. The use of economic

information in defining NOAA's performance measures will also suggest ways to redefine NOAA's missions. These are currently defined as:

> *NOAA's historical role has been to predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship.*

If the economic information suggested in this paper were available, NOAA's missions could include such ideas as building and sustaining wealth from ocean resources, enhancing the value of living in and visiting coastal communities, and providing useful information about the oceans and atmosphere to a wide variety of audiences.

This latter point is particularly noteworthy since the advent of the Internet and the ease of transmitting information makes NOAA much more than a provider of information to the scientific community. The National Weather Service has always had this role, but increasingly parts of NOAA such as the National Data Buoy Center are providing their information directly to the public. This expansion of NOAA's service roles is creating new kinds of economic values that should be explicitly acknowledged as part of gaining a broader understanding of NOAA's economic roles.

Using these strategies, it should be possible to build an economic perspective into NOAA's policy development and assessment in all areas of the agency's activities. Doing so will require both a "top down" and a "bottom up" approach. Agency leadership needs to make clear that efforts to build economic perspectives into policy development will be supported, and resources needed to acquire and manage the information will be forthcoming within reasonable limits. NOAA staff and line managers must be both empowered and educated to what economic approaches mean in terms of improving their own performance. This must be done while recognizing that economics, indeed the social sciences in general, are *terra icognita* for much of NOAA's staff, who are more likely to be trained in the physical sciences and natural resource management areas. Only a combined effort of leadership and staff is likely to successfully broaden NOAA's perspectives to better connect the agency to the people it serves.

References

Chen, C., and B. McCarl, 2000. "The Value of ENSO Information to Agriculture: Consideration of Event Strength and Trade." Department of Agricultural Economics, Texas A&M University.

Colgan, Charles. S. and Hauke Kite-Powell The Economic Benefits of Regional Ocean Observing Systems: The Case of the Gulf of Maine Ocean Observing System. Washington: NOAA Office of the Chief Economist.

Government Accounting Standards Board. Concepts Statement 2: Service Efforts and Accomplishments Reporting. See: http://accounting.rutgers.edu/raw/seagov/pmg/perfmeasures/categori.html.

Kaplan and Norton. 2000. "The Balanced Scorecard: Measures That Drive Performance". Harvard Business Review. January.

Khalanski M. 1997. Industrial and ecological consequences of the introduction of new species in continental aquatic ecosystems: the zebra mussel and other invasive species. *Bulletin Francais de la Peche et de la Pisciculture* 0 (344-345): 385-404

Manne, A.S. and R. Richels, 1992. *Buying Greenhouse Insurance*. MIT Press. Cambridge MA.

McNew, K., 1999. "The Value of El Nino Forecasts in Agricultural Commodity Markets: The Case of U.S. Corn Storage." University of Maryland.

Nordhaus, W.D., 1994. *Managing the Global Commons: The Economics of Climate Change. MIT Press*. Cambridge MA.

Osborne, David and Ted Gaebler. 1992. *Reinventing Government* Reading, Mass: Addison, Wesley.

National Partnership for Reinventing Government 1999 Balancing Measures: Best Practices in Performance Management. http://govinfo.library.unt.edu/npr/library/papers/bkgrd/balmeasure.html

Newcomer, Kathryn 1994. "Measuring Government Performance" in Wholey, Joseph S., Hatry, Harry P., and Newcomer, Katheryn E., *Handbook of Practical Program Evaluation*. San Francisco: Jossey-Bass.

OTA. 1993. *Harmful Non-Indigenous Species in the United States*. Washington, DC: Office of Technology Assessment, United States Congress.

Peck, S.C., and T.J. Teisberg, 1993. "Global Warming Uncertainties and the Value of Information." *Resource and Energy Economics*. 15:71-97.

Solow, A.R., R.F. Adams, K.J. Bryant, D.M. Legler, J.J O'Brien, B.A. McCarl, W. Nayda, and R. Weiher, 1998. "The Value of Improved ENSO Prediction to U.S. Agriculture Chen and McCarl 2000." *Climatic Change* 39:47-60.

Thor, Carl G. 2000. "The Evolution of Performance Measurement" *Government Journal of Cost Management*. May/June.